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(54) Sensing apparatus

(57) Sensing apparatus for distinguishing between single and double fed documents moving along a path employs light source 11 and light sensor 1... of the path... state in respon... opposite sides leading edge of a ... set to a first to the opposite state ...ing of the small amount of light is ...nd is set across the path as the docu...atively passes the light sensor. A signa... representative of detection of a do... feed of documents is temporarily stored. If the flip-flop has not been set to the opposite state by the time the trailing edge of the document passes the sensor, a signal is provided to indicate that the detection of the double feed is inappropriate and the light source is set at too high a brightness value for the documents being handled.

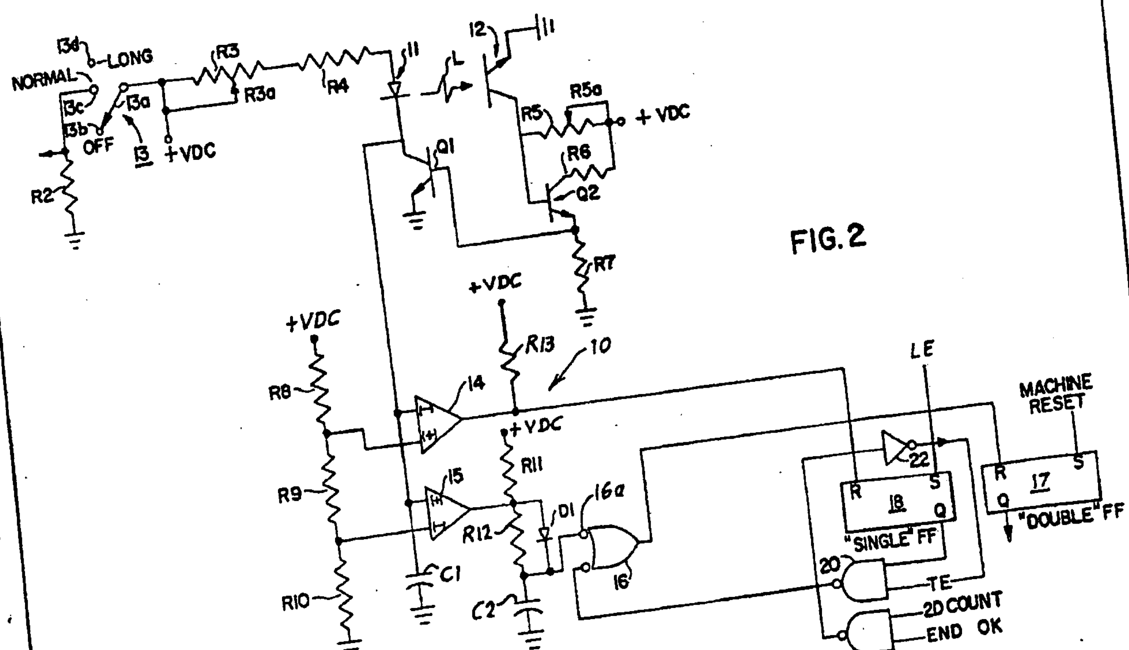

FIG. 2

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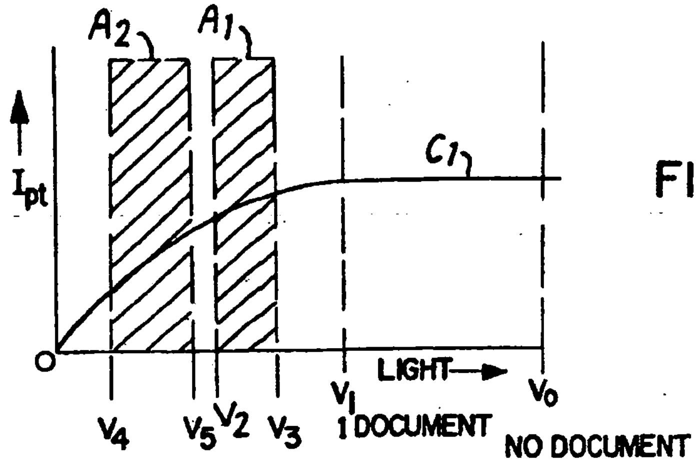


FIG. 1b

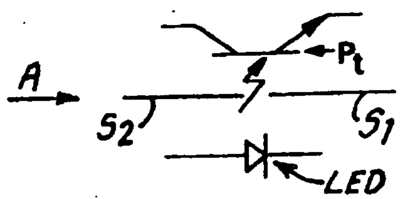


FIG. 1a

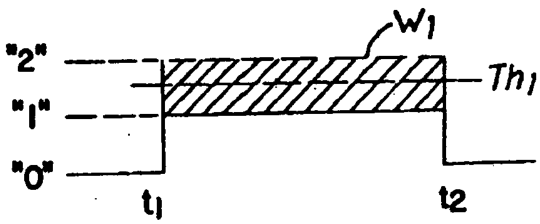


FIG. 1c

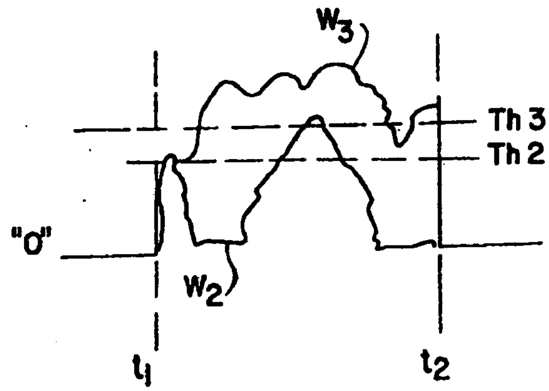


FIG. 1d

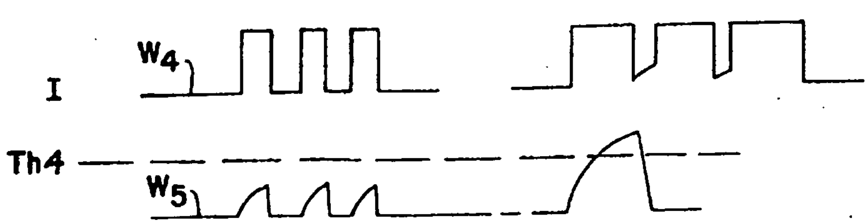


FIG. 1e

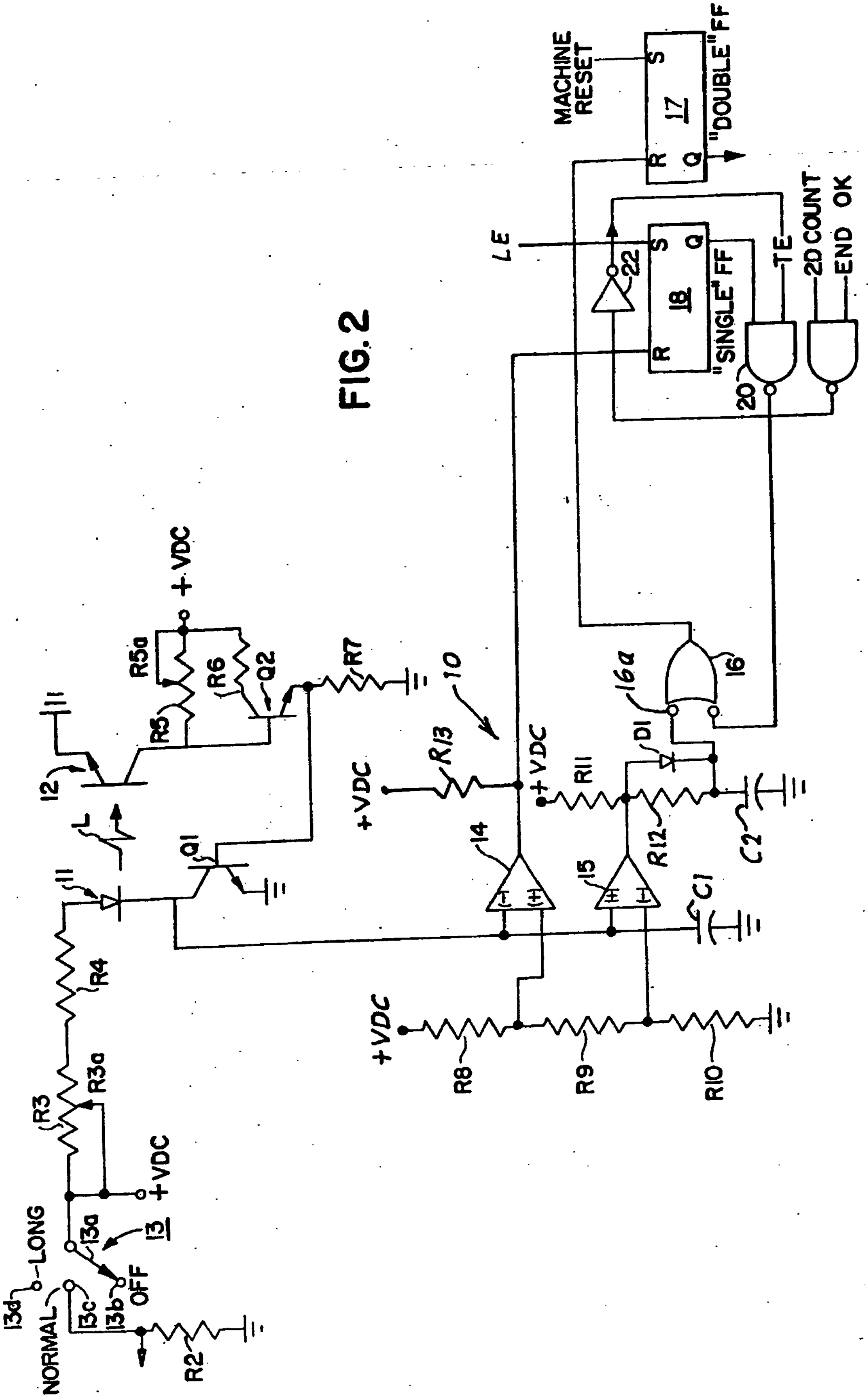

MACHINE RESET
S
17
R
Q
"DOUBLE" FF
LE
S
Q
18
"SINGLE" FF
R
22
TE
2D COUNT
END OK
20
+VDC
R5a
R6
Q2
R5
R7
12
10
L
11
Q1
R13
+VDC
R11
D1
16a
16
14
15
R12
C2
C1
R4
R3a
R3
+VDC
R8
R9
R10
13a
13
LONG
13d
NORMAL
13c
13b
OFF
R2

FIG. 2

FIG.3a

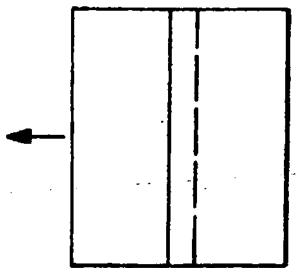
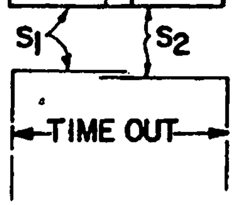


FIG.3b



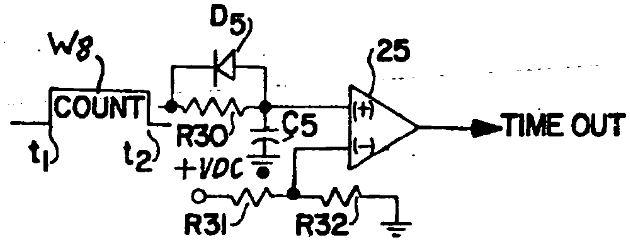


FIG.3

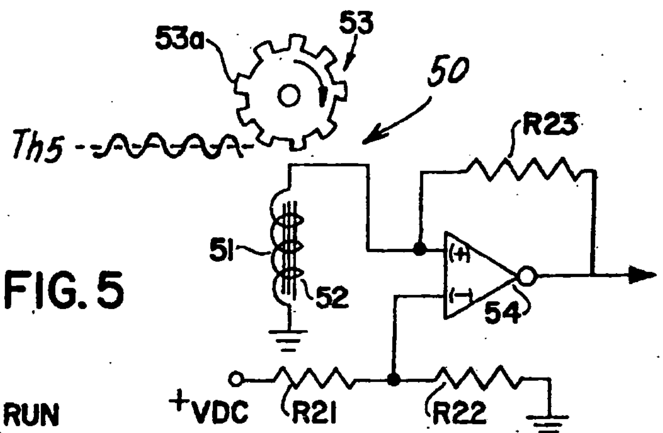


FIG. 5

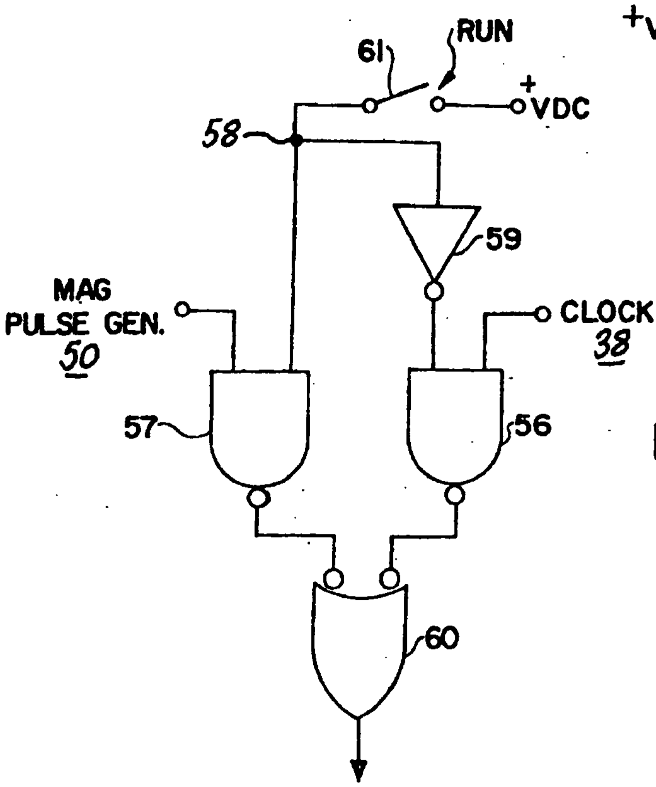


FIG.6

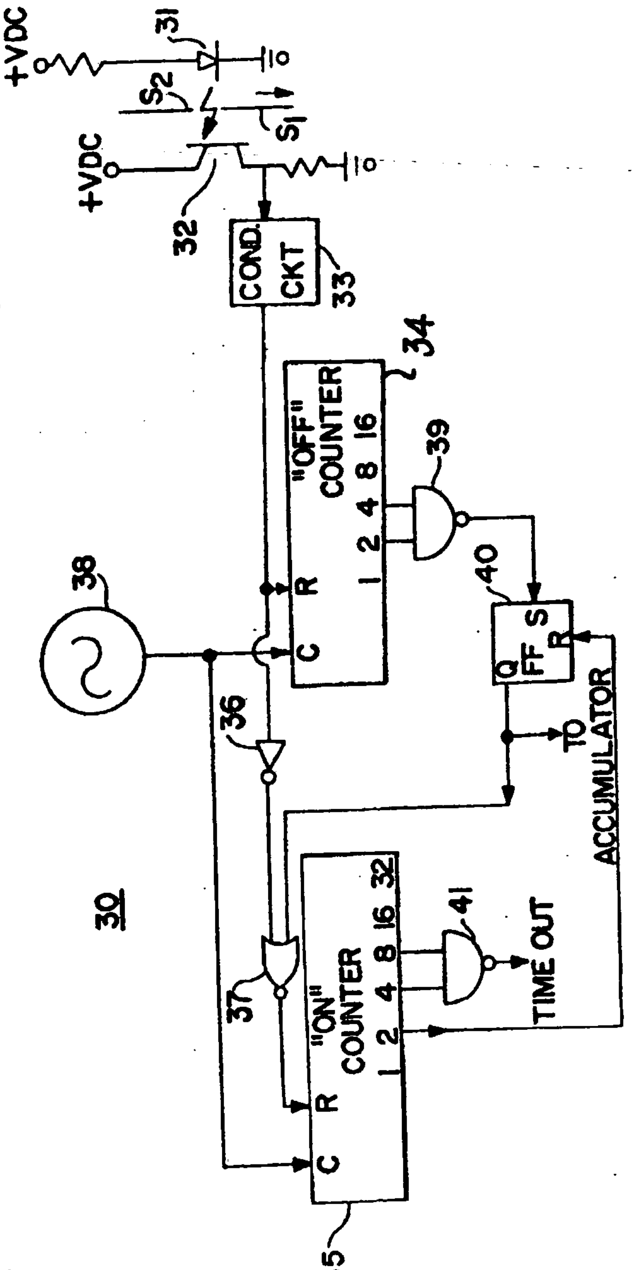

+VDC
31
S2
S1
+VDC
32
COND. CKT
33
"OFF" COUNTER
1 2 4 8 16
34
39
38
C
R
40
FF
Q
S
R
TO ACCUMULATOR
36
30
37
"ON" COUNTER
1 2 4 8 16 32
41
TIME OUT
35

FIG.4

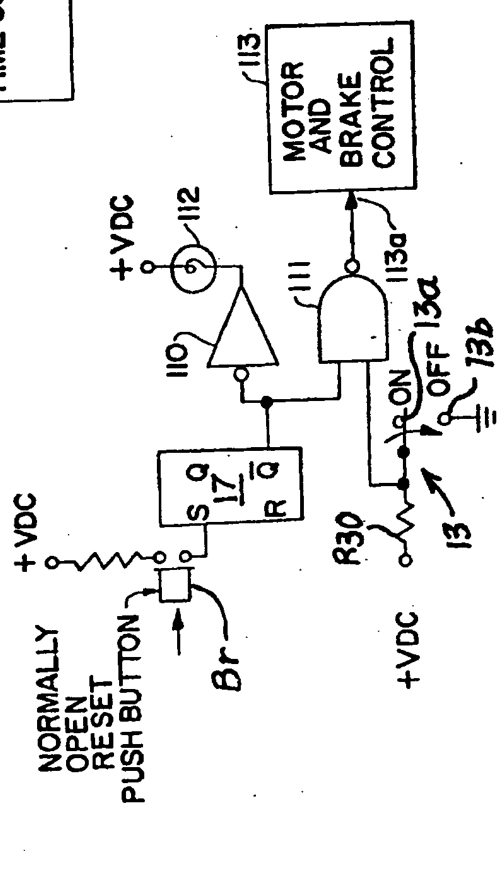

+VDC
112
110
111
113a
MOTOR AND BRAKE CONTROL
113
13a
13b
ON
OFF
S
17
Q
R
R30
13
+VDC
NORMALLY OPEN RESET PUSH BUTTON
Br

FIG.8

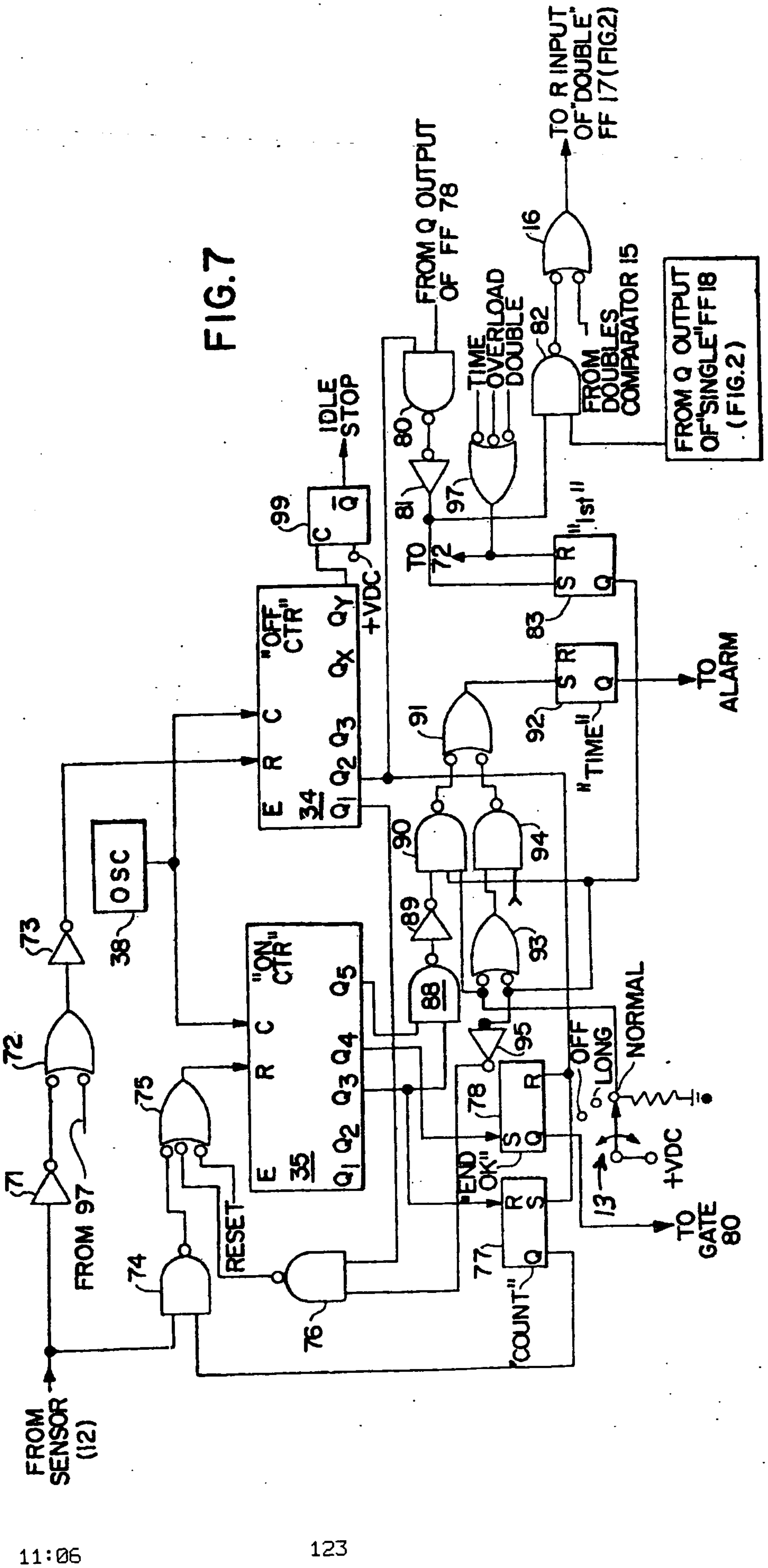

FROM SENSOR (12)
FROM 97
RESET
"COUNT"
"END OK"
OSC
"ON CTR"
"OFF CTR"
IDLE STOP
+VDC
TO 72
FROM Q OUTPUT OF FF 78
TIME
OVERLOAD
DOUBLE
"1st"
"TIME"
TO ALARM
TO GATE 80
OFF LONG
NORMAL
FROM DOUBLES COMPARATOR 15
FROM Q OUTPUT OF "SINGLE" FF 18 (FIG.2)
TO R INPUT OF "DOUBLE" FF 17 (FIG.2)

FIG.7

SPECIFICATION

Sensing apparatus

This invention relates to sensing apparatus for distinguishing between single and double fed documents, particularly but not exclusively in electronic counting and control systems for counting documents, such as money, which include detecting means which are sensitive to the transmissivity of light.

In document handling devices of the type described for example in our U.S. Patent No. 4,054,092 issued October 18, 1977, there is taught apparatus for bottom feeding of documents placed in an infeed hopper, including feed means and stripper means for separating documents and feeding them toward an outfeed stacker on a one at a time basis, the stripping action serving to ensure the delivery of single fed documents under normal conditions. As the documents leave the feeding and separating region, they come under the influence of acceleration means which aburptuly accelerates the document which has just left the influence of the drive and stripper means so as to form a gap of at least a predetermined length between the document being accelerated and the next succeeding document to be accelerated. This gap is utilized, in conjunction with light means such as an LED and light sensing means such as a photo-transistor to detect the change in brightness in order to distinguish the movement of a document between the light source and light sensing element from the passing of a gap therebetween. The documents continue to move from this location where they are neatly stacked in an outfeed stacker.

In many operations it is quite often necessary to be absolutely assured that the document count be exact. For example, when counting currency and especially when counting currency of large denominations, an error in the count of documents, no matter how small, is nevertheless cause for great concern.

One of the problems which contributes to the possibility that errors might occur is the possibility that the currency, when in use, may acquire or have deposited thereon sticky or adhesive material or may have creases or other mutilations which cause two documents to adhere to one another and to fail to separate even as a result of the stripping operation. If two such documents are fed so that one is directly super-imposed upon the other, the apparatus may count this anomaly as a single document, thus throwing off the count. It is therefore imperative in many applications to provide means for positively and reliably detecting such conditions. See, for example, U.S. Patent No. 3,025, 771 in which means sensitiv to light receive light when a single bank note is fed and receive no light when there are overlapping bank not s, the receipt of no light resulting in an indication that overlapping documents are being fed. that the documents being counted may be vastly different in age and amount of use, as well as the fact that they may be fed in any on of four different orientati ns, the problem of distinguishing single fed documents is compounded.

According to the present invention, there is provided sensing apparatus for distinguishing between single and double fed documents moving along a feed path at spaced intervals so that the trailing edge of each document is spaced from the leading edge of the next succeeding document, the apparatus comprising:

light intensity sensing means including a light sensing element positioned to one side of said path;

a light source positioned on the opposite side of said path and aligned so that its light rays are directed toward said light sensing element;

a bistable flip-flop;

means responsive to the leading edge of a document to set a first output of said flip-flop to a first state;

means coupled to said light intensity sensing means and responsive to the light-transmissivity across said path as detected by said light intensity sensing means being below a predetermined threshold for setting said flip-flop first output to the opposite state, and which means is prevented from setting the flip-flop first output to said opposite state when the detected light-transmissivity is above said threshold;

means for temporarily storing a doubles feed condition;

means for generating a trailing edge signal when the trailing edge of a document has passed said sensing means; and

gating means responsive to the first state at said first output of said flip-flop when a trailing edge signal occurs to store an "artificial" doubles feed condition in said storing means indicating that the doubles feed detection circuit is improperly set at too high a brightness value for the documents being handled.

Various parts of a document handling device incorporating apparatus according to the inventi n will now be described by way of example with reference to the accompanying drawings, in which:

Figures 1a through 1e show plots useful in describing the circuitry of the apparatus;

Figure 2 is a schematic diagram of the apparatus;

Figure 3 is a schematic diagram of a time-out circuit for identifying overlapping documents in the document handling devic ;

Figure 4 is a schematic diagram showing a counting apparatus of th document handling device;

Figure 5 shows a magn tic sensing circuit which may be utilized with the counting apparatus of Figure 4;

Figure 6 shows circuitry for sel cting one of th circuits of Figures 4 and 5 to drive the counters;

Figure 7 is a schematic of another version of

the counting apparatus of Figure 4; and

Figure 8 is a schematic diagram of a modification f the circuit of Figure 7 which can be used to enable a semi-automatic brightness setting operation.

The electronic sensing and control circuitry to be described herein in detail is useful with document handling and counting devices and specially that apparatus taught in our U.S. Patent No. Re 29,470 reissued November 8, 1977.

A detailed description of the document handling and counting apparatus described therein will be omitted herein for purposes of simplicity. For purposes of understanding the present invention it is sufficient to understand that such apparatus accepts documents in an infeed hopper, advances the documents to a combination of feeding and stripping rollers which corrugate the documents i.e. urge them into an undulating configuration so as to cause the documents to be fed single file through the feeding and stripping rollers in order to be advanced to acceleration rollers for abruptly accelerating the feeding velocity of the documents to provide gaps of a predetermined dimension between adjacent edges th reof, the distance of length of said gaps being m asured in the feed direction. A suitable light source such as a LED and a light sensitive means such as a photo-transistor, are positioned on opposite sides of the path of movement of the d cuments after the afore-mentioned gaps are formed for the purpose of counting the documents.

Apparatus of the type described hereinabove is capable of handling and counting documents at speeds of the order of over 600 to 1200 documents per minute thus yielding a device which is extremely advantageous for use in counting and/or endorsing items such as checks, food stamps, paper currency, coupons and the like.

Since documents of the above mentioned categories may have rather significant value such as, for example, paper currency, in applications wherein it is desired to form batches of the paper currency of a predetermined quantity, it is extremely important to be able to form and count such batches with the highest precision which is practical of being obtained. In many situations the capability of forming batches of precise quantities may not be the fault of the equipment. For example, two bills may stick together as a result of having been folded or creased or having come into contact with a glue, adhesive or other sticky substance which makes it a practical impossibility to separate the paper currency even when using the most advanced equipment available. It thus becomes extremely advantageous to provide apparatus for det cting the presence of double fed d cum nts in rd r to abruptly halt the equipment and thereby identify the double fed condition, typically by causing the double f d documents to be the last ones fed into the outfeed hopper.

The technique utilized for doubles detection is to provide a light source such as the LED shown in Figure 1a and a photo-transistor Pt respectively arranged on opposite sides of the path of movement of documents as represented by arrow A. Th figure shows two such documents S_1 and S_2 moving in the direction shown by arrow A as a result of the document handling apparatus referred to hereinabove and disclosed in U.S. Patent No. Re 29,470. Light from the LED is directed toward the photo-transistor which functions in a manner such that its conductivity changes in direct proportion to the magnitude of light striking the photo-transistor. The plot shown in Figure 1b shows a curve C_1 representing the relationship between increasing intensity of light reaching the photo-transistor and plotted against the current generated by the photo-transistor. Curve C_1 can be seen to reach a plateau at a light intensity value V_1 which basically indicates that the transistor has saturated. Thus any increase in intensity of light above the value V_1 causes an insignificant change in the magnitude of current generated by the photo-transistor. The vertical line through the value V_0 represents the intensity of light when no documents are passing between the LED and the photo-transistor. It can be seen that the amount of light intensity generated by the LED should preferably be regulated so as to cause the photo-transistor Pt to function at and below the "knee" portion of curve C_1 so as to generate the most significant differences in current magnitude responsive to the amount of light transmitted through single fed documents and double fed documents. Assuming proper regulation, the cross-hatched area A_1 which lies between the intensity values V_2 and V_3, respresents the range of brightness or light intensity reaching the photo-transistor after passing through a particular type of document which, for example, may be United States paper currency of one dollar denomination. The right hand end of this range, i.e., the value V_3, represents the amount of light intensity reaching the photo-transistor for new, clean paper currency while the value V_2 represents the amount of light reaching the photo-transistor during the time in which an old one dollar bill is passing therebetween, the drop in light intensity reaching the photo-transistor being a function of the smudges or other foreign matter which may have accumulated on the bill as a result of its length of use and the type of handling it has undergone.

In a similar fashion, the cross-hatched area A_2, defined by the vertical lines V_4 and V_5, represents the range of light intensity reaching the photo-transistor from the LED when two double fed bills pass therebetween. In a similar fashion, the right hand end V_5 of intensity range represents the double feeding of two crisp new bills while the left hand end V_4 of the range represents the feeding of two old and well used bills. Other factors tending to effect light intensity are the orientation of the bills and combination of orientation of two bills when double fed.

As a practical matter, although the two areas A_1 and A_2 are shown as being separate from one another, it should be understood that it is common

t expect that these ranges will in fact verlap, which is m re the rule than the exc ption, thus further complicating the discrimination of single and double feeds.

In any case, it is most advantageous to control the light intensity reaching the photo-transistor to lie within the limits of the positive slope at and below the "knee" of curve C_1 in order to be assured that the largest differences in current output of the photo-transistor are developed to more easily distinguish between each of the possible feed conditions. For example, if the LED were operated so that light intensity for the single fed and double fed bills whose ranges are given by the cross-hatched areas A_1 and A_2, were to be shifted for example to the region between the values V_1 and V_0, even though changes in intensity occur over this range, the current output of the photo-transistor can be seen to change insignificantly and, as a practical matter not at all, so as to provide no practical method for detecting the difference between single fed and double fed documents. The aforesaid adjustment is controlled by providing suitable current control or current limiting means as will be more fully described hereinbelow.

Turning to a consideration of Figure 1c, the "ideal" condition is shown therein wherein the waveform W1 represents the signal obtained during the passage of a paper document (such as U.S. paper currency) between the LED and the photo-transistor Pt after amplification and inversion by an amplifier, wherein at time t_1 the leading edge of a square pulse is generated and the pulse reaches a value "1" in the presence of a single bill. The level remains constant at "1" over the entire length of the bill (assuming the "ideal" bill has a uniform light transmission characteristic over its surface) and at time t_2 the trailing edge of the square pulse is formed at which time the trailing edge of the document passes the LED and phototransistor.

In a similar fashion, presuming two such "ideal" bills are firmly glued together, the dotted curve of Figure 1c results wherein at time t_1, the leading edge of the waveform W_1 is generated and the square pulse reaches a value of "2", remains constant until time t_2 at which time the trailing edge is formed as the two double fed documents pass beyond the LED and photo-transistor. These very ideal wave shapes make it a simple matter to compare the resulting signals for single and double fed documents in a comparator by establishing a threshold level represented by the dotted line Th_1 which is preferably half the distance between the values "1" and "2", i.e. which is one and one half ($1\frac{1}{2}$) volts presuming the other values to be one volt and two volts respectively.

Although th above solution is most satisfactory wh n dealing with "ideal" bills and conditions, as a practical matter this does not represent the true conditions obtained during document handling and counting. The more realistic picture is represented by the waveforms W_2 and W_3 shown in Figure 1d.

From a consideration of these two waveforms which more truly represent actual operating conditions, it becomes much m re difficult to establish a threshold level which can be relied upon to distinguish double fed documents from single fed documents in every case. For example, considering the threshold level represented by dotted line Th_2, although the curve W_3 can be seen to lie above this level for a greater period of time than waveform W_2, it can nevertheless be seen that the waveform W_2 does make transitions which surpass this level. By setting an even higher threshold Th_3 it can be seen that the waveform W_3 does not lie above this threshold level over the entire time interval and in fact the waveform W_2 can be seen to rise above this threshold level for at least a brief portion of the time internal t_1-t_2.

However, it has been observed that when the proper threshold level is selected for the type of bills being handled, single fed documents will make only a few transitions above the threshold level while double fed documents will make a number of transitions above the threshold level said number being significantly greater than the transitions made by the single fed documents. Thus it is possible through the circuitry to be described to achieve a high precision doubles detection circuit through filtering and comparator techniques which are embodied in the doubles detection circuitry 10 shown in Figure 2 which is comprised of LED 11 and photo-transistor 12. The adjustment for the type of documents being handled is provided for by adjustable resistor R3 having adjustable arm R3a. One terminal of resistor R3 is connected to voltage source +VDC. The opposite terminal of resistor R3 is coupled through fixed resistor R4 to the anode of LED 11, whose cathode is coupled to the collector of transistor Q1.

The photo-transistor 12 has its emitter coupled to ground and has its collector coupled in common to the base of transistor Q2 and one terminal of adjustable resistor R5, whose other terminal is connected in common to the source +VDC and to the collector of Q2 through resistor R6. The emitter of Q2 is coupled to ground through R7 and to the base of transistor Q1 whose emitter is coupled to ground and whose collector is coupled to the cathode of LED 11. The transistors Q1 and Q2 form an inverting amplifier and constitute a feedback means between the photo-transistor 12 and the LED 11.

The operation of this circuit is as follows:

When energized, the maximum intensity of the light L emitted from LED 11 is controlled by the adjustment of resist r arm R3a. With this basic adjustment, light of a pred termined intensity is directed toward photo-transistor 12. The amount of light reaching ph to-transistor 12 is dep ndent upon the light transmission characteristics of the document (or documents) passing therebetween. Presuming the light transmission characteristic is high, the photo-transistor will approach saturation causing maximum or near maximum current to be

present in the collector circuit, developing a large IR drop across R5, dropping the voltage at the base of Q2. This results in a drop in the emitter current, causing a small IR drop to be developed across R7 thereby dropping the voltage applied to the base of Q1. The above-described circuit coupled to LED 11 automatically regulates (and in this case drops) the current flow therethrough so as to regulate the intensity of its light output. Obviously for low light intensity, the reverse operation occurs wherein when a low magnitude current flows through photo-transistor 12 a small IR drop develops across R5 developing a larger voltage applied to the base of Q2 and hence a larger IR drop across R7, increasing the voltage applied to the base of Q1 and thereby increasing the current through the LED 11 and hence the brightness of the light output.

This unique circuit utilizes the feedback technique described hereinabove for the purpose of maintaining the output of the photo-transistor substantially constant and significantly reducing the output of LED 11 so as to greatly increase its useful operating life.

The output developed by the collector of Q1 is in fact utilized as the signal which may be said to be equivalent to those signals represented by the waveforms W_2 and W_3 of Figure 1d.

This signal level is applied to the inverted input of a first comparator 14 and to the noninverted input of a second comparator 15. The non-inverted input of comparator 14 is coupled to the voltage source +VDC through resistor R8 which together with fixed resistors R9 and R10 form a voltage divider circuit which provides the threshold voltage levels, as will be more fully described.

A capacitor C1 couples the inverted input of comparator 14 and the noninverted input of comparator 15 to a reference potential as shown.

The output of comparator 15 is coupled between the terminals of resistors R11 and R12 as shown. Resistor R11 is coupled to the voltage source +VDC while the resistor R12 is coupled to reference potential through capacitor C2. A diode D1 is coupled in parallel across resistor R12. The common terminal between R12 and C2 is coupled to one input 16a of NOR gate 16 which is coupled to the reset input R of bistable flip-flop 17.

The output of comparator 14 is coupled to voltage source +VDC through resistor R13 and the output is further coupled in common to the reset input R of a bi-stable flip-flop 18.

The operation of the first comparator circuit comprised of comparator 15 is as follows:

Light emitted from LED 11 is directed toward photo-transistor 12. The intensity of the light reaching photo-transistor 12 is a function of the light transmission characteristic f the bill or other document passing therebetween. The automatic adjustment of light output intensity for LED 11 is controlled by the feedback circuit comprised of transistors Q1 and Q2 and their associated resistors R5 and R7, as was described hereinabove.

The output signal from the sensing circuit is taken from the collector of Q1 and is applied to the non-inverting input of comparator 15. A threshold level is established at the inverting input of comparator 15 by means of the voltage divider resistors R8 through R10, connected in series between +VDC and ground reference. The signal transitions above the threshold level cause the comparator to generate the square pulse signals shown in Figure 1e which result from the passage of single bills and double fed bills, respectively.

The square pulse output signals are sustained so long as the transistions are above the threshold level as shown by waveform W_4 for single fed documents. The current output as shown by waveform W_4 is directly coupled through diode D1 to capacitor C2 which charges at a rate established by the resistors R11 and R12 and diode D1 in circuit therewith.

The individual pulses are integrated as shown by the waveform W_5. However, it can be seen that these pulses are significantly separated in time and are each individually brief in duration so that the pulses do not combine with one another to exceed a threshold level Th_4 determined by the characteristics of the NOR gate 16. The capacitor C2 discharges through the resistor R12 and the comparator 15 each time the pulses drop below the threshold level for the comparator 15.

On the other hand, when double fed documents pass between LED 11 and photo-transistor 12, the duration of either single transitions alone or taken together with the number of transgressions occurring, combine to raise the output signal at terminal 16a of NOR gate 16 to a level above threshold Th_4 sufficient to provide a signal indicative of the passage of double fed documents.

This signal is applied by NOR gate 16 to the reset input R of the bi-stable flip-flop 17, whose set input S is coupled to reset means which functions to reset the document handling device after the occurrence of a double fed document condition in readiness to clear this condition and begin counting again.

When the threshold level Th_4 is reached, the output of NOR gate 16 goes negative causing the bi-stable flip-flop 17 to be reset whereby the signal level at its Q output serves to energize an audible alarm and a braking circuit which halts the handling of documents following the double fed documents so that the last documents to be fed to an outfeed hopper are the double fed documents.

As was mentioned above, it is necessary to select the threshold level so that the apparatus is in actuality set for the detection of doubles fed documents for the type of documents being run.

For example, the operator may begin to run docum nts through th documents handling and counting apparatus with ut paying direct attention to the last setting of the doubles detector device which setting may be the improper setting for the type of documents being run.

Thus the doubles detector circuit includes

comparator 14 which serves the function of preventing the erroneous processing of documents in the following manner:

If the brightness limit of LED 11 is set too high, then single fed documents will not produce a signal which is applied to the (–) input of said comparator 14 which is sufficient to exceed the (+) input threshold voltage. Thus, no output will be produced to reset the flip-flop 18, and this will thereby indicate a double. On the other hand, if the brightness limit of the LED 11 is set too low, even though comparator 14 will reset flip-flop 18, comparator 15 will provide a tripping signal (on gate 16) even when handling single fed documents.

The output of comparator 14 is coupled to the reset input R of bi-stable flip-flop 18 whose set input S receives an input indicative of the presence of the leading edge of the document. This sets the bi-stable flip-flop 18 so that its Q output is high. When single document detection occurs, a signal applied to reset input R of bi-stable flip-flop 18 causes the output Q to go low. This signal level is applied to one input of NAND gate 20, whose other input receives a signal indicative of the fact that the trailing edge of the document has passed the photo-transistor 12. In the event that a single document detection has not occurred, the Q output of bi-stable flip-flop 18 will remain high, which condition develops a low level at the output of NAND gate 20 when photo-transistor 12 detects the trailing edge of the document which, when coupled through NOR gate 16, applies a reset signal to the reset input R of the bi-stable flip-flop 17 to provide a level at the Q output of this flip-flop indicative of the fact that double fed documents have passed between LED 11 and photo-transistor 12. Thus an automatic means is provided for indicating a double fed document condition even when such condition does not really exist, in order to halt the apparatus and alert the operator to move the control knob to the proper setting for the type of documents being handled. Since this "artificial" condition will occur for single fed documents, the condition will occur each time a single fed document passes through LED 11 and photo-transistor 12 to absolutely ensure that the operator will direct attention to the setting of the doubles sense circuit.

Since conditions sometimes arise wherein documents are not fed so that one is exactly on top of the other but overlap each other only partially, it is important to detect this condition since the overlapping clearly prevents these two docum nts from being detected and counted as two documents, the result being that the documents will be detected as one unusually "long" document. In order to be apprised of this condition, the circuitry of Figure 3 may be employ d. Figure 3a shows the manner in which two such documents S1 and S2 may overlap, Figur 3b showing the side view thereof. The manner of such detection is to select a time out period of a duration greater than the time required pass between the counting sense circuit. The counting sense circuit is comprised of basically th same elements, i.e. an LED 11 and a photo-transistor 12 arranged on opposite sides of the path of movement of the documents through the document handling and counting apparatus. A count pulse is generated as represented by the waveform W_8 of Figure 3, which pulse is at the "1" level over the length of the document or over a time interval t_2—t_1 which is equal to the time required for the document to pass between the LED photo-transistor combination. The positive level pulse is integrated through resistor R30 and capacitor C5, whose common terminal is coupled to the non-inverting input of a comparator 25. Th inverting input is coupled to a common terminal between resistors R31 and R32 coupled between the +VDC voltage source and ground for establishing the proper threshold level at the non-inverting input. If the count pulse has a pulse interval greater than that for single fed documents, the threshold level will be surpassed causing the development of a timeout signal at the output of comparator 25. For example, let it be assumed that the documents being handled have a length of 2.5 inches measured in the feed direction. Thus the maximum length of two such documents which overlap very very slightly is approximately 5.0 inches. By selecting a threshold level less than the time required for a 5 inch document to pass between the photo-transistor and LED and significantly greater than the time required for a single fed document to pass therebetween, an adequate timeout signal will be provided to sense this condition and abruptly halt the equipment. In one preferred example, the timeout may be a time interval which is equivalent to the travel of a document of about 4.5 inches length so that an overlappage of the order of 0.60 inches will provide an indication of this condition. This capability is coupled with the capability of detecting the presence of documents which are fed in overlapping fashion and which overlap over a significantly greater portion of their surface area, and enables the production of a doubles sense output signal even for documents which may b overlapping slightly in such a manner that the overlapping portions are those with the highest overlapping light transmissive characteristics, and therefore may otherwise go undetected.

Figure 4 shows a circuit for counting the documents. This circuit can also be used to provide an indication of overlapping documents, as an alternative to the use of integrating circuits as in the arrangement of Figure 3. The counting circuit 30 is comprised of an LED 31 and a photo-transistor 32, similar to those described hereinabove in connection with Figures 1 and 2, but now being utilized for th purpose of counting the documents. The current output of photo-transistor 32 is a functi n of the light impringing th reon, with th two maj r light levels being a reduced light level when a document is postioned between LED 31 and photo-transistor 32 and a higher magnitude light level when a gap is aligned

with elements 31 and 32.

The output signal level appearing at the emitter of 32 is passed through a conditioning circuit 33 of a kn wn type which establishes a satisfactory threshold level for differentiating between the presence of a gap and the presence of a document so as to be able to compare the output level of the photo-transistor with the threshold level through suitable comparator means as shown for example in Figure 3a of the aforementioned reissued patent and thereby generate a signal which, when at a first discrete level, is indicative of the passage of the document and when at a second discrete level is indicative of the passage of a gap between elements 31 and 32. The output of the conditioning circuit 33 is coupled directly to the reset input R of multi-stage counter 34 and is further coupled to the reset input of multi-stage counter 35 through inverter 36 and NOR gate 37. Counters 34 and 35 may be characterized as "OFF" and "ON" counters, respectively, indicative of the fact that they respectively count pulses when a gap and when a document are passing between the elements 31 and 32. In the presence of a gap, the level at the reset input R allows counter 34 to accumulate pulses from a master clock 38 capable of generating constant frequency pulses at a frequency for example, of the order of 500 pulses per second. These pulses will continue to be accumulated whereby a predetermined number of pulses are indicative of the presence of a gap of suitable length. This condition may be detected through the utilization of a decoder gate 39 coupled to one or a plurality of selected output stages of the counter so that when that count is reached, the counter will provide the desired output. In the example given, it is assumed that when six such pulses from master clock 38 are accumulated, a gap of adequate length has been detected. Thus, the output of gate 39 goes low causing the triggering of bi-stable flip-flop 40 which temporarily stores a count pulse. Its Q output is coupled through NOR gate 37 to provide the proper level at the reset input of "ON" counter 35 as will be more fully described.

As soon as the gap has been terminated and the document begins passing between elements 31 and 32, the level applied to the reset input R of "OFF" counter 34 maintains the counter continuously in the reset condition preventing pulses from master clock 38 from being accumulated therein. However, this level is inverted by inverter means 36 and applied through gate 37 to the reset input of counter 35 which is now permitted to accumulate pulses from master clock 38 for th interval during which a document is passing between the elem nts 31 and 32. As was m ntioned hereinabove, through the accumulation of an appropriat number of pulses indicative of the fact that an unusually "l ng" document is passing between elements 31 and 32, this condition is detected by decoder gate 41 to generate the tim out signal referred to hereinabov in conjunction with Figure 3. One output of the "ON" counter may also be utilized to reset bi-stable flip-flop 40 in preparation for the n xt count to be developed therefrom. The Q output of flip-flop 40 is utilized to couple a count pulse to an accumulator (not shown) for providing a count of the total number of documents processed by the document counting and handling device. As an alternative arrangement to the pulsing of the counters 34 and 35 by master clock 38, these counters may be pulsed through the use of the magnetic sensor assembly 50 as shown in Figure 5. The magnetic sensor comprises a coil 51 wound about a magnetic pole piece 52 having at least a portion or one end thereof positioned immediately adjacent to the teeth 53a of a magnetic timing gear 53 which is mounted upon the shaft of one of the rollers utilized to drive the documents being handled through the document handling and counting device. For example, the magnetic timing gear may be securely mounted to the shaft 24 of the acceleration roller identified by designating number 38 in Figure 2a of the above mentioned patent No. 4,054,092. In one preferred embodiment, the timing gear may have 64 gear teeth and a two inch diameter so that each count in the counter will represent a travel distance of the order of 0.08 inches. As the gear teeth pass the gear sensor winding 51, a current is developed therein as represented by the waveform W_7.

The signal represented by waveform W_7 is applied to the non-inverting input of comparator 54, whose inverting input is coupled to the common terminal between resistors R21 and R22, connected in series between the voltage source VDC and ground reference, thus establishing the threshold level represented by the dotted line Th_5 shown in Figure 5. The resulting pulses are simultaneously applied to the clock inputs C of counters 34 and 35 in place of the pulses developed by master clock 38 shown in Figure 4. The advantages of this circuit reside in the fact that since the document handling and counting device of the above mentioned United States Patent No. 4,054,092 positively drives the documents with effectively no slippage, instead of measuring time and converting time into distance with the use of master clock 38, the magnetic sensing circuit directly measures distance thereby directly measuring the size or length of the document with greater accuracy.

Thus, regardless of whether an overlap, gap, timeout or doubles feed condition occurs, the frequency of the pulses will be a direct function of the operating speed of the device and no reduction in quality or accuracy will occur due to any changes in the operating speed of the d cument handling and counting device either because of changes in speed du to deliberate speed change adjustments provided for by manual means or due to vagaries or spurious conditions within the system thereby providing a generating means whose pulses are a function of the operating speed, i.e., rotating speed of the shaft upon which the magnetic timing gear is mounted to provide a more accurate sensing means than

the mast r clock 38.

In applicati ns where it is desired to select between the two generating sources, the switching circuitry of Figure 6 may be employed wherein clock pulses from the master oscillator 38 are applied to one input of NAND gate 56 while pulses from the magnetic sensor 50 are applied to NAND gate 57. An input terminal 58 is coupled directly to the remaining input of NAND gate 57 and is coupled to the remaining input of NAND gate 56 through inverter 59. The outputs of NAND gates 56 and 57 are coupled to respective inputs of the NOR gate 60 and by appropriate positioning of the run switch 61 it is possible to select either master clock 38 or the magnetic pulse generator 50 to operate the apparatus for respective applications wherein constant speed operation is to be regularly employed allowing for the selection of the master clock whereas when operation with speed changes will be required or desired the output of the magnetic pulse generator 50 may be selected. Although there has been described herein the use of a light sensor or alternatively the use of a magnetic sensor for counting purposes, any other suitable sensing means may be employed.

The gates 39 and 41 may be omitted and the accumulated count may be taken directly from one of the outputs of the counter stages (i.e. "1", "2", "4", "8", etc.). Also an accumulated count from either the "ON" or the "OFF" counters 35 and 34 may be employed to generate the pulse representing the count of a document.

As a further alternative, a predetermined count accumulated in the "OFF" counter may be employed to allow the "ON" counter to be reset. For example when a document passes between elements 31 and 32, count pulses from the clock 38 are accumulated in counter 35. If a punched hole or the like passes between the elements 31 and 32 it will cause the light intensity reaching photo-transistor 32 to increase to appear as a "gap". However, when the length of the punched hole is much less than the length of a gap, it is preferred that, even if the counter 35 stops accumulating pulses, the count accumulated to that point should not be lost, to permit the count to be resumed in cases where punched holes or other perforations are detected.

Figure 7 shows the circuitry for accomplishing this objective, like elements as between Figures 4 and 7 being designated by like numerals.

When no "gap" or "hole" is detected, the low level of document sense photo-transistor is coupled through inverter 71 and NOR gate 72 and inverter 73 to apply a high level to the reset input "R" of OFF counter 34 preventing the OFF counter from accumulating c unts. The low level is also coupled to one input of NAND gate 74 which maintains the output of NAND gate 74 high. This high output drives the output of NOR gate 75 low to enable ON counter 35 to accumulate count pulses from master clock 38.

When four counts are accumulated, the Q3 output of counter 35 applies a pulse to reset input R of flip-flop 77 driving its Q output low, and thus applying a low level t the other input of NAND gate 74 to maintain its output high and thereby maintain the output of NOR gate 75 low to allow counts to continue to be accumulated, the accumulation of four counts being assumed to identify a valid document.

When a "hole" is detected the input to inverter 71 goes high causing the outputs of inverter 71, gate 72 and inverter 73 to go low, high and low, respectively, enabling OFF counter 34 to accumulate a count while ON counter 35 continues to accumulate counts at the pulse rate. When eight pulses are accumulated by the counter 35, the Q4 output, coupled to the set input S of flip-flop 78, sets the flip-flop to apply a high level to NAND gate 80 causing inverter 81 to apply a high level to one input of NAND gate 82 and the set input S of FIRST DOCUMENT flip-flop 83.

Gates 82 is coupled through NOR gate 16 (see Figure 2) to reset the DOUBLES flip-flop 17 (see Figure 2).

When the count in ON counter 35 reaches 20 the Q3 and Q5 outputs go high, driving the output of NAND gate 88 low and thus applying a high to one input of NAND gate 90 through inverter 89. The middle input of gate 90 is high when flip-flop 83 is set. The remaining input is high when the switch 13 is set to the appropriate position for handling normal documents causing the output of NAND gate 90 to go low, and driving the output of NOR gate 91 high to set the Q output of TIME flip-flop 92 high which is employed to turn off the document handling device motor and activate an alarm to indicate that the document passing the sensor is too long (i.e. that there are overlapping documents).

When either the long size documents setting is chosen, by moving the switch means 13 to the proper position, or the first document is being counted, the output of NOR gate 93 goes high, and when the count in ON counter 35 reaches 32 the output of NAND gate 94 goes low enabling gate 91 to set the TIME flip-flop 92 to activate the alarm and turn off the motor as was described above.

The FIRST DOCUMENT flip-flop 83 is employed to provide an additional delay when the document handling device is restarted after clearing a jam or completing a batch of documents whereupon the device has stopped, leaving the leading edge of the next document to be passed between the count sensor 12 (see Figure 2) a distance typically in the range from 0.125 inches to 0.75 inches from the sensor 12.

The device must accelerate this document from a rest condition to normal operating speed which requires more time for this document to pass the sensor 12 than succeeding docum nts. This problem is not ncounter d when using a magn tic pulse generator of the type shown in Figure 5.

The FIRST DOCUMENT flip-flop 83 has its Q output set low when a batch is completed, when

the manual reset is depressed or when an idle stop signal is generated. Any one of these conditions are passed by NOR gate 97 to the reset input R of flip-flop 83 to set its output low and prevent flip-flop 92 from generating an output indicative of a "long" document.

The Q output of flip-flop 83 is also coupled through inverter 95 to drive one input of gate 76 high so that the first count of OFF counter 34 drives its output low causing gate 75 to place a high level on the reset input R of ON counter 35 to prevent the counter from accumulating any counts. When two counts are accumulated by OFF counter 34, its Q2 output applies a signal to set input S of FIRST DOCUMENT flip-flop 83 through gate 80 the inverter 81 to drive the Q output high. Inverter 95 thus places a low level on one input of gate 76 so that the output goes high to cause gate 75 to remove the reset level from reset input R of ON counter 35 enabling count pulses to be accumulated. This operation provides a delay of a time sufficient to allow the first document to accelerate to normal counting speed without accumulating a number of counts representative of a long document.

An accumulated count of two in OFF counter 34 is used to reset flip-flop 78 and set flip-flop 77. The setting of flip-flop 77 enables the ON counter 35 to be reset, by gate 74, as a gap passes the sensor.

The OFF counter 34 is preferably provided with a sufficient number of stages to provide a count at output Qx to generate a signal indicating a gap of about 250 millisecond length to sound an alarm identifying an unusually long gap between documents and an output Qy which sets a flip-flop 99 whose $\overline{Q}$ output goes high to stop the handling and counting device when a "gap" of 15 seconds duration is detected, indicating that no documents have been counted for that period.

The circuitry shown in Figure 7 can also be modified to incorporate the arrangement of Figure 8 to provide for highly simplified calibration of the doubles detection level.

For example, when changing from one type of document to another, it is important to set the doubles detector adjustable resistor element R3 to be sure that the light element 11 (see Figure 2) emits light of the proper intensity to prevent a single fed document from erroneously creating a doubles detection fed signal and likewise to prevent a doubles fed condition from failing to generate a doubles detection signal.

This is accomplished by moving switch arm 13a to its OFF position. Documents are run with the knob (R3A) set to enable light element 11 to provide its brightest output.

The stationary (OFF) contact 13b couples resistor R30 to ground reference placing a low level at one input of NAND gate 111 (Figure 8). This keeps the output of NAND gate 111 high regardless of the level at its remaining input. A motor braking circuit 113 is responsive to a low level at its input 113a to stop the feeding of documents. Thus the OFF position of the doubles detection switch 13 prevents the doubles condition from affecting the motor control circuit even if a doubles condition is sensed.

An observalbe DOUBLES condition capability is provided by the current driver circuit 110 and "DOUBLES" lamp 112. Whenever a doubles condition is sensed (as described in connection with Figure 2) the $\overline{Q}$ output of the flip-flop 17 in the doubles detection circuitry goes high to apply a high level to current amplifier 110 and gate 111. The high level applied to the current amplifier 110 causes lamp 112 to light providing a visual indication of a double feed condition, regardless of the fact that the doubles detection switch 13 is ON or OFF — when ON the gate 111 will be enabled to create a low condition at its output when both of its inputs are high to activate the motor control circuit 113 and turn the motor of the document handling device off and preferably activate braking means (not shown) in addition thereto. These capabilities from part of the apparatus described in the above mentioned U.S. Patents. For example, see motor M and brake 131 in Figure 2 of U.S. Patent No. 3,857,559.

The circuitry of Figure 8 may also be used to great advantage as semi-automatic means for adjusting the brightness level when the type of documents being processed are changed.

To accomplish the adjustment the doubles detection swith 13 is moved to the OFF state to prevent any turn-off of the unit in the event of any double feeds.

A control knob provided at an accessible position on the machine to move switch arm R3A (see Figure 2) can be rotated counterclockwise to set element 11 for its highest light output (i.e. for the darkest or least light transmissive documents). If the light output is too high, flip-flop 18 is prevented from being reset by comparator 14 to indicate the presence of a double.

On turning the doubles setting control knob to the dark setting (i.e. for very thin or highly light transmissive documents) comparator 15 will cause even a single document to provide a double feed signal. Adjustment is made by turning the doubles setting control knob from this setting so that the brightness of the element 11 slightly increases and running the documents through again. If the lamp lights again, the operation is repeated until the lamp 112 remains off, thereby yielding a simple and yet rapid method for setting the proper threshold level.

Whenever lamp 112 is lit, it may be turned off by depressing normally-open reset button Br to reset the DOUBLES flip-flop 17 (Figures 2 and 8).

The arrangement of Figure 8 provides the equipment with the additional capability of being able to run documents at high speed and be advised of the occurrence of a doubles condition (or conditions) each time lamp 112 lights, without stopping the equipment each time. Stacks of documents yielding a doubles indication may be set aside for evaluation at a later time, enabling counting and processing to continue at high speed with no stopping but with a doubles sensing

capability continuously monitoring the processing operation.

The apparatus described above is also described, and certain aspects thereof claimed, in copending parent application No. 47620/78, and other divisional applications Nos.

CLAIMS

1. Sensing apparatus for distinguishing between single and double fed documents moving along a feed path at spaced intervals so that the trailing edge of each document is spaced from the leading edge of the next succeeding document, the apparatus comprising:

light intensity sensing means including a light sensing element positioned to one side of said path;

a light source positioned on the opposite side of said path and aligned so that its light rays are directed toward said light sensing element;

a bistable flip-flop;

means responsive to the leading edge of a document to set a first output of said flip-flop to a first state;

means coupled to said light intensity sensing means and responsive to the light-transmissivity across said path as detected by said light intensity sensing means being below a predetermined threshold for setting said flip-flop first output to the opposite state, and which means is prevented from setting the flip-flop first output to said opposite state when the detected light-transmissivity is above said threshold;

means for temporarily st ring a doubles feed condition;

means for generating a trailing edge signal when the trailing edge of a document has passed said sensing means; and

gating means responsive to the first state at said first output of said flip-flop when a trailing edge signal occurs to store an "artificial" doubles feed condition in said storing means indicating that the doubles feed detection circuit is improperly set at too high a brightness value for the documents being handled.

2. Apparatus according to claim 1, further comprising switch means having an on and an off position;

gating means responsive to the off position of said switch means and to the storage of a doubles feed condition in said storing means for generating a motor control signal; and

means responsive to the motor control signal for halting the feeding of documents.

3. Sensing means for distinguishing between single and double fed documents moving along a feed path at spaced intervals so that the trailing edge of each document is spaced from the leading edge of the next succeeding document substantially as described and shown in the accompanying drawings.

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